

7

Docket: 81450

Inventors: Bruce L. Ha
Thomas C. Burgo

Attorney: Raymond L. Owens

EXPRESS MAIL LABEL NO.:EL485200346US

Date of Mailing: September 15, 2000

[illegible]

WOBBLE SIGNAL DETECTION CIRCUIT WITH IMPROVED
CAPACITY TO REPRODUCE ATIP INFORMATION AND OPTICAL DISK
APPARATUS HAVING SUCH

BACKGROUND OF THE INVENTION

The present invention generally relates to wobble signal detection circuits and optical disk apparatus having such, and more particularly, to a wobble signal detection circuit for detecting an Absolute Time In Pregroove (ATIP) signal from an optical disk such as a compact disk recordable (CD-R) in an optical disk apparatus, and an optical disk apparatus having such.

Optical disks of a direct-read-after-write type include two types: write-once and erasable. With respect to a write-once optical disk, data is written thereon mainly by focusing a light beam into a spot on a data recording surface of the disk made from tellurium (Te) or bismuth (Bi) so as to form a pit in the disk at the location of the spot, or by focusing a light beam into a spot on a data recording surface of the disk made from Sb_2Se_3 , TeO_x or a thin film of organic dye so as to alter reflectivity of the disk at the location of the spot.

A CD-R, which is a write-once optical disk, includes a number of pregrooves as guiding tracks. The pregrooves radially wobble slightly at a center frequency of 22.05 kHz. Address information during recording called ATIP is multiplexed and recorded in the pregrooves by frequency shift keying (FSK) with a maximum deviation of ± 1 kHz.

During recording of data onto and reproduction

5

10

15

25

30

The signal (C+D) is subtracted from the signal (A+B) so that an output signal $(A+B) - (C+D)$ is obtained. Then, the output signal $(A+B) - (C+D)$ is compared with a reference voltage, so that a binary wobble signal is obtained.

However, the gain and offset of a sample-and-hold circuit are inconsistent among the individual circuits, and cause errors in the output level of the sample-and-hold circuit. Therefore, the waveforms of the sampled and held detection signals A, B, C and D include the sampling noises having different levels. For example,

However, the gain and offset of a sample-and-hold circuit are inconsistent among the individual circuits, and cause errors in the output level of the sample-and-hold circuit. Therefore, the waveforms of the sampled and held detection signals A, B, C and D include the sampling noises having different levels. For example,

5 Therefore, the sampling noise remains in the output signal
(A+B) - (C+D) as shown in FIG. 1C. As the sampling is
performed at higher speed, the noise level of the sampling
noise becomes higher. Therefore, when a recording speed
becomes so high that the sampling noise cannot be ignored,
10 there arises a problem of deterioration in performance of
reproducing the ATIP information from the wobble signal.

It is a general object of the present invention
15 to provide a wobble signal detection circuit and an
optical disk apparatus having such in which the above-
described disadvantage is eliminated.

The above objects of the present invention are achieved by a wobble signal detection circuit for an optical disk apparatus detecting a wobble signal by focusing a light beam into a spot on a pregroove on an optical disk during recording of data onto and reproduction of data from the optical disk and including a photodetector which detects first and second lights from first and second portions of the spot, respectively, and outputs first and second detection signals corresponding to respective power levels of the first and second lights.

15 According to the above wobble signal detection
circuit, the wobble signal is obtained by reducing the
sampling noise components of the detected signals output
from the sample-and-hold circuit. Therefore, a sampling
noise component of the wobble signal can be reduced
20 effectively, thus achieving the improved capacity to
reproduce ATIP information.

The above objects of the present invention are also achieved by a wobble signal detection circuit for an optical disk apparatus detecting a wobble signal by focusing a light beam into a spot on a pregroove on an optical disk during recording of data onto and reproduction of data from the optical disk and including a photodetector which detects first and second lights from first and second portions of the spot, respectively, and outputs first and second detection signals corresponding to respective power levels of the first and second lights, the first and second portions being formed by splitting the spot into two portions in parallel with a scanning

5 gain adjustment means for adjusting noise levels of noise components included in the respective first and second detection signals to approximately the same level, the noise components being generated by sampling the respective first and second detection signals in the sample-and-hold circuit; and subtraction means for
10 calculating a difference between the first and second detection signals respectively output from the gain adjustment means.

The above objects of the present invention are also achieved by an optical disk apparatus for recording data onto and reproducing data from an optical disk by detecting a wobble signal by focusing a light beam as a spot onto a pregroove on the optical disk, the optical disk apparatus including: a photodetector which detects first and second lights from first and second portions of the spot, respectively, and outputs first and second detection signals corresponding to respective power levels of the first and second lights, the first and second portions being formed by splitting the spot into two portions in parallel with a scanning direction; and a wobble signal detection circuit, the wobble signal detection circuit including: a sample-and-hold circuit sampling and holding the first and second detection signals output from the photodetector during the recording of the data onto the optical disk; lowpass filter means for reducing noise components of the first and second detection signals, the noise components being generated by sampling the respective first and second detection signals

in the sample-and-hold circuit; and subtraction means for calculating a difference between the first and second detection signals respectively output from the lowpass filter means so as to obtain the wobble signal.

5 The above objects of the present invention are further achieved by an optical disk apparatus for recording data onto and reproducing data from an optical disk by detecting a wobble signal by focusing a light beam into a spot on a pregroove on the optical disk, the
10 optical disk apparatus including: a photodetector which detects first and second lights from first and second portions of the spot, respectively, and outputs first and second detection signals corresponding to respective power levels of the first and second lights, the first and
15 second portions being formed by splitting the spot into two portions in parallel with a scanning direction; and a wobble signal detection circuit, the wobble signal detection circuit including: a sample-and-hold circuit sampling and holding the first and second detection
20 signals output from the photodetector during the recording of the data onto the optical disk; gain adjustment means for adjusting noise levels of noise components included in the respective first and second detection signals to approximately the same level, the noise components being
25 generated by sampling the respective first and second detection signals in the sample-and-hold circuit; and subtraction means for calculating a difference between the first and second detection signals respectively output from the gain adjustment means.

30

BRIEF DESCRIPTION OF THE DRAWINGS

Other objects, features and advantages of the present invention will become more apparent from the

0053955-004000

FIGS. 1A through 1C are diagrams showing waveforms of signals for illustrating the way a sampling noise is reduced in a conventional wobble signal detection circuit;

FIGS. 3A through 3F are diagrams showing
10 waveforms of signals for illustrating the way the sampling
noise is reduced in the conventional wobble signal
detection circuit and in embodiments of the present
invention;

FIG. 5 is a block diagram of a wobble signal detection circuit according to a second embodiment of the present invention; and

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 4 is a block diagram of a wobble signal detection circuit according to a first embodiment of the present invention.

When the light beam is focused into a spot on the pregroove 10 shown in FIG. 2, the detector parts 12A, 12B, 12C and 12D detect the reflected beam, and supply the

The sample-and-hold circuit 14 which is also supplied with a mode selection signal from a CPU 100 is switched OFF in the above-described first and third modes to pass the supplied detection signals as outputs, while switched ON in the above-described second mode to sample, hold and output the supplied detection signals. The detection signals A and B detected by the respective detector parts 12A and 12B are output from the sample-and-hold circuit 14 to be added by an adder 16, and the detection signals C and D detected by the respective detector parts 12C and 12D are output from the sample-and-hold circuit 14 to be added by an adder 18.

15 [Output signals (A+B) and (C+D) of the adders 16
and 18 are supplied to lowpass filters (LPF) 40 and 42,
respectively. The LPFs 40 and 42 each of which is also
supplied with the mode selection signal from the CPU 100
are switched OFF in the first and third modes to pass the
20 supplied signals as outputs, and are switched ON in the
second mode to cut off high-frequency components of the
supplied detection signals having frequencies higher than
the wobble signal frequency of 22.05 ± 1 kHz by using, for
example, a cutoff frequency of 24 kHz. The sampling noise
25 is a high-frequency component having a frequency of 200
kHz or higher.

In the first mode, the output signals (A+B) and (C+D) of the adders 16 and 18, after passing through the LPFs 40 and 42, are supplied to a subtracter 20 via coupling capacitors C1 and C2, respectively. The subtracter 20 subtracts the output signal (C+D) from the output signal (A+B), and supplies a difference between the two output signals to a terminal 21 of a switch 22 as an

On the other hand, in the third mode, the LPFs 40 and 42 are switched OFF, and a terminal 23 of the switch 22 is selected. An output signal (A+B+RF) of the adder 16 including an RF signal reproduced from the CD-R is supplied to a voltage-controlled amplifier (VCA) 34, while an output signal (C+D+RF) of the adder 18 including the reproduced RF signal is supplied to a VCA 36. An automatic gain control (AGC) circuit 35 performs feedback control so that an amplitude of the output signal (A+B+RF) of the VCA 34 has a predetermined level. Similarly, an AGC circuit 37 performs feedback control so that an amplitude of the output signal (C+D+RF) of the VCA 36 has the predetermined level.

A subtracter 38 subtracts the output signal (C+D+RF) of the VCA 36 from the output signal (A+B+RF) of the VCA 34. By this subtraction, the reproduced RF signals included in the respective signals A, B, C, and D are offset, and the difference between the two output signals (A+B+RF) and (C+D+RF) is supplied to the terminal 23 of the switch 22 as an output signal (A+B) - (C+D).

As the terminal 23 is selected in the third mode, the output signal $(A+B) - (C+D)$ is supplied to the BPF 24 for the reduction of unnecessary frequency components, and is further supplied to the HPF 26 via the coupling capacitor C3 for further reduction of unnecessary frequency components. Thereafter, the output signal $(A+B) - (C+D)$ is compared with the reference voltage V_{ref} by the comparator 28 and is output from the terminal 32 as the binary wobble signal.

Further, in the second mode, the sample-and-hold circuit 14 and the LPFs 40 and 42 are switched ON, and the terminal 21 of the switch 22 is selected. As shown in FIG. 3A, the power of the light beam alternately repeats the write power state (the maximum value) and the read power state (the minimum value). When the light beam is in the read power state, the sample-and-hold circuit 14 samples and holds the detection signals at the sampling timings corresponding to the rising edges of the sampling pulse signal as previously described with reference to FIGS. 3B and 3C.

The output signals from the sample-and-hold circuit 14 each include the sampling noise, so that the output signals $(A+B)$ and $(C+D)$ of the adders 16 and 18 have the waveforms shown in FIGS. 3D and 3E, respectively. However, as the sampling noises of the output signals $(A+B)$ and $(C+D)$ are reduced by the LPFs 40 and 42, the subtracter 20 calculates the difference between the output signals $(A+B)$ and $(C+D)$, and outputs the signal $(A+B) - (C+D)$ having the waveform with reduced sampling noise as shown in FIG. 3F.

As the terminal 21 is selected, the output signal $(A+B) - (C+D)$ is supplied to the BPF 24 for the reduction of unnecessary frequency components, and is

0053055-001000

5

10

15

25

30

5

10

20

25

30

On the other hand, in the third mode, the gain adjustment circuits 50 and 52 are switched OFF, and the terminal 23 of the switch 22 is selected. The output signal $(A+B+RF)$ of the adder 16 including the reproduced RF signal is supplied to the VCA 34, while the output signal $(C+D+RF)$ of the adder 18 including the reproduced RF signal is supplied to the VCA 36. The AGC circuit 35 performs feedback control so that the amplitude of the output signal $(A+B+RF)$ of the VCA 34 has the predetermined level. Similarly, the AGC circuit 37 performs feedback control so that the amplitude of the output signal $(C+D+RF)$ of the VCA 36 has the predetermined level.

The subtractor 38 subtracts the output signal
25 (C+D+RF) from the VCA 36 from the output signal (A+B+RF)
from the VCA 34. By this subtraction, the reproduced RF
signals included in the respective detection signals A, B,
C and D are offset, and the difference between the two
output signals (A+B+RF) and (C+D+RF) is supplied to the
30 terminal 23 of the switch 22 as the output signal (A+B) -
(C+D). As the terminal 23 is selected in the third mode,
the output signal (A+B) - (C+D) is supplied to the BPF 24
for the reduction of unnecessary frequency components, and

5

10

20

30

The microcomputer 64 generates a recording power control signal, which is converted into an analog signal in a D/A converter 82 to be supplied to a recording circuit 84 as a recording power control voltage. A signal to be recorded is input to an encoder 86 and encoded using CIRC based on the control of the microcomputer 64, and is supplied to the recording circuit 84.

The present invention is not limited to the

The present invention is not limited to the

For example, according to the above-described
5 embodiments, the present invention is applied to the CD-R,
which is a write-once optical disk. However, the
recording medium is not limited to the CD-R, and an
erasable disk can replace the CD-R if an ATIP signal is
included therein.

15